TREES AND SEASONS IN A CHANGING WORLD

SWATI SIDHU

Trees live close to us — in our backyards, gardens, fields, and road-sides. Their lives are intimately connected to the environment they grow in, an environment we know is changing. How are trees coping with the changing climate and weather patterns?

On an early April morning, the higher slopes of mountains in Kumaon are hidden under a layer of frost. The only ones to dare the precipitous slopes are nomadic pastoralists and their nimble-footed animals. It is to them that the mountains reveal the heavy scarlet blooms of *burans* (see **Fig. 1**). The emergence of these flowers marks the onset of spring, and colors the slopes and paths. The bloom attracts birds and bees (for pollination in return for some sweet nectar) and people (the flowers are used locally to make a *sherbet*). But all is not well with these Himalayan trees. The mountains are not unaffected by the climatic changes that are taking place in the surrounding world, and *burans* are beginning to flower as early as January.[1] The change in the flowering rhythm of this iconic tree is likely to send ripples through the mesh of complex interactions that exist among the many plants, animals, and people who inhabit these mountains.

Trees are intimately linked to the environment

Trees flower at a time when they have a good chance of being pollinated, produce fruits at a time when their seeds have a good chance of being dispersed, and germinate at a time when there are plentiful resources to do so. In some tree species, this behaviour is seasonal — with a clear flowering and fruiting cycle.[2] For e.g., the *semal* tree (*Bombax ceiba*) flowers in winter, after most of its leaves have fallen (see **Fig. 2**). Its bright red flowers are very attractive to birds that hang around

sipping nectar and pollinating them.[3] Its fruit burst open to release seeds during the dry windy months of March and April, when they are dispersed far and wide. Tree species that are not seasonal in their flowering or fruiting behaviour, produce a few flowers at a time, but continue doing so for many months at a stretch.[2] For e.g., some fig trees can be seen to flower and fruit at any given time in a year.

Both these strategies offer distinct advantages. Species that flower and fruit during brief periods, do so generously, attracting a horde of pollinators and dispersers to this bounty. They also manage to limit the damage caused to their leaves and flowers, by animals that come to feed on them, to specific time intervals in a year. In contrast, trees that do not have a distinct flowering season keep their pollinators busy throughout the year, increasing their chances of reproduction.

Since all these stages are linked in the life-cycle of trees, success at any one stage determines the success of subsequent stages. Thus, an intimate relationship exists between trees, their environment, and the animals around them.

Seasonality in Indian trees

In India, we broadly experience four seasons — winter (December to March), summer (April to June/July), monsoon (June/July to September), and post-

Fig. 1. The bright red flowers of Rhododendron.

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Fig. 2. A *Bombax ceiba* tree in full bloom. The large showy flowers attract several birds such as mynas, drongos, parakeets.

Credits: Dr. Raju Kasambe, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Bombax_ceiba_Silk_Cotton_by_Dr._Raju_Kasambe_IMG_0073_(2).jpg. License: CC-BY-SA.

monsoon (October to November). Depending on where we live, we may experience a longer summer (north-western India), an earlier monsoon (southern and north-eastern India), or a colder winter (northern and central India). In the peninsula and the north-eastern region, we may also experience up to two distinct rainy seasons or monsoons (see **Box 1**). So, based on which part of the country we are in, we can divide a year into a number of seasons that make sense in that context, nevertheless, monsoons will be at the heart of such an activity.

Box 1. Indian monsoons:

Caused by temperature differences between land and oceans, monsoons are a very important weather phenomenon, restricting water availability across the subcontinent to certain months in a year. Trees in different regions and habitats prepare for this seasonality and availability of rainfall in different ways.

The south-west monsoons (June to September) build up because the land surface is warmer than the ocean surface in summers. This creates an area of low pressure over land that pulls cool, moisture-laden air from the oceans to it. As the air from the oceans travels over land, it warms up, rises in altitude, and cools. As it cools, its capacity to hold moisture reduces, causing rain over much of India.

The north-east monsoons (December to March) arise because the land surface, in the northern part of the Indian subcontinent, is cooler than the ocean surface in winters. This creates an area of higher air pressure over land, causing wind to travel from it towards the ocean. These winds, traveling towards the Indian Ocean, pick up moisture from the Bay of Bengal and cause rain over peninsular India.

Monsoons are expected to be strong drivers of climatic patterns in the country as well as seasonality in leafing and flowering among trees. For e.g., seasonal drought and moisture conditions, created due to the monsoons, impact leaf-shed and leaf-flush cycles. These, in turn, have been shown to be linked to flowering and fruiting in trees.[4]

Observations of some common trees in India show that they have very different seasonality patterns. The Indian almond tree (*Terminalia catappa*) sheds its leaves during winter. Remarkably, the old leaves are replaced by fresh green leaves within a matter of days (see **Fig. 3**). On the other hand, *Kulu* (*Sterculia urens*), a tree that does well in dry places, remains leafless for more than half the year (see **Fig. 4**). Trees also flower at different times in a year. Some tree species flower during winter, using the dipping temperatures or decreasing day length as flowering cues. Some flower at the end of winter, as the days get longer and temperatures rise. Others flower during the rains, using water availability as a flowering signal or cue. For e.g., the Himalayan cherry (*Prunus cerasoides*) flowers at the beginning of

Fig. 3. A *Terminalia catappa* **tree in a north Bengaluru neighbourhood:** in January **(a)**, and two weeks later in February **(b)**. Within a matter of days the old red leaves fall, and get replaced by fresh green leaves.

Fig. 4. *Sterculia urens* undergoes long leaf-less (a) and short leafy (b) phases. This tree grows in drought-prone places and survives by remaining leaf-less for several months in a year.

Credits: Pushar04, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Sterculia_urens_raigad_maharashtra_2.jpg. License: CC-BY-SA.

Credits: J.M. Garg, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Sterculia_urens_W_IMG_1914.jpg. License: CC-BY-SA.

Fig. 5. Himalayan cherry (*Prunus cerasoides*) in full bloom at the beginning of winter in Meghalaya.

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winter (see **Fig. 5**), the Indian laburnum (*Cassia fistula*) flowers in summer (see **Fig. 6**), and Babool (*Acacia nilotica*) flowers with the first shower of rains (see **Fig. 7**).

Interestingly, a study of flowering periods of over 100 tree species across both the drier and wetter parts of India showed that a majority (56%) flowered between March and June, as the temperature and day length increase.[5] This study also used leaf-flush and leaf-fall patterns in dry tropical trees to show that new leaves start appearing in the drier part of the year, about a month or two before the monsoons arrive. While it may seem counter-intuitive

Fig. 6. Amaltas (*Cassia fistula*) in full bloom at the beginning of summer.

Credits: Swati Sidhu, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Cassia_fistula_Meghalaya.jpg. License: CC-BY-SA.

Fig. 7. Babool (*Acacia nilotica*) begins to flower with the first showers of rain.

Credits: J.M Garg, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Babool_(Acacia_nilotica)_flowers_at_Hodal_W_IMG_1248.jpg. License: CC-BY-SA.

to grow new leaves in a dry season, trees may do this to get a head start. Even in trees where the process of leaf production starts at the beginning of summer, leaf buds have been observed to develop and expand rapidly when the rains arrive. Thus, while leaf budding is largely due to changes in day length and temperature, the growth and survival of leaves, flowers, and fruits are largely affected by changes in rainfall.

Changing tree rhythms

Today, we frequently hear of extreme weather events — occurring as extremely high or low temperatures, as well as unexpected droughts or floods caused by too little or too much rain. These climatic changes are affecting trees world-wide and in many ways — one such impact is on their flowering patterns.[6] For e.g., data collected through citizen–science efforts in Kerala shows that Indian laburnum (*Cassia fistula*), which is known to flower seasonally around *Vishu* (the Malayali new year), is now flowering all-round the year with irregularities in peak flowering times.[7] Similarly, the Himalayan rhododendron (*Rhodendron arboreum*) and Flame of the forest (*Butea monosperma*), which are known to flower during March-April, are now flowering as early as January.

Not only do changes in the environment affect plant life directly, they also trickle down the network of relationships that bind them. The animals that tree species depend on for pollination and seed dispersal also show seasonal rhythms — needing specific food resources at certain times in a year, especially when they are breeding or nesting. For e.g., hornbills, large fruit-eating birds, nest inside tree cavities. While the female seals herself inside the nest to raise her young, the male brings nutritious fruits to feed the mother and the young ones during the nesting period. For the hornbill chicks to hatch and fledge successfully, the nesting period in hornbills needs to match the production and availability of fruits in the forest. Thus, any change in tree flowering or fruiting patterns is also likely to have an immediate effect on the survival and growth of these chicks.

Knowing changes in our environment

One way to understand changes in our immediate environment is by observing tree rhythms. This is not new — people from different parts of the world have been observing flowering and leafing in trees, and keeping records of these events. For e.g., records of flowering in cherry trees from Kyoto, Japan, date back 1200 years. These records reflect the cultural significance of these beautiful and ephemeral blossoms, as *hanami* — the practice of viewing and sitting under the blossoms — is deeply embedded in Japanese society (see **Fig. 8**). Scientists have compiled the flowering records of these cherry blossoms over centuries to show that this species is now flowering earlier than it used to, and that this change corresponds with a rise in springtime temperatures.[8]

Documenting long-term observations of this kind is vital to our understanding of the changes taking place in our world. Given the scale of work required for the observation and documentation of every known tree species, such efforts need the support of members of the public. This has led to many large-scale citizen science efforts, like the USA National Phenology Network and

Fig. 8. People enjoying the sight of cherry blossom trees flowering in Tokyo.

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The European Phenology Network, which encourage interested members of the public to observe and record phenological events of trees species in their vicinity. SeasonWatch (www.seasonwatch.in) is a similar project in India, where participants, especially children, adopt and watch trees in their neighbourhoods and/or school campuses and record flowering, fruiting, and leafing patterns of the adopted trees. Participating in these efforts offers each one of us the opportunity to partner in developing a common understanding of climate change, and being better prepared to engage with decisions that affect the health of our planet.

Key takeaways

- Trees flower when they have a good chance of being pollinated, fruit when their seeds have a good chance of being dispersed, and germinate when there are plentiful resources to do so.
- Since flowering, fruiting, and germination are linked in the life-cycle of trees, success in one stage determines the success of subsequent stages.
- The seasonality of trees is also influenced by the environment. While leaf budding may be linked to changes in day length and temperature, the growth and survival of leaves, flowers, and fruits are largely affected by changes in rainfall.
- Extreme weather events, which characterise anthropogenic climate change, disturb the flowering and fruiting patterns of trees.
- The impacts of these disturbances in tree rhythms trickle down a network of ecological relationships by affecting the various animals (e.g., insects, birds and humans) that depend on flowers and fruits at specific times of the year to survive and thrive.
- Documenting changes in tree patterns is crucial in developing a common understanding of climate change, but this task requires massive manpower.
- Many citizen science efforts (like SeasonWatch) offer us the opportunity to partner in efforts aimed at being better prepared to engage with decisions that affect the health of the planet.

Life in your Backyard

LOOKING AT A TREE

1. With a friend or family member, find a tree in your school or close to your home that you can observe safely for ten minutes.
2. Does it have leaves, flowers, or fruits? What is their colour?
3. Quietly and carefully observe your tree. Do you see any animals? Which part of the tree are they on? What are they doing?
4. Look for old leaves fallen under your tree. Pick up a couple of them.
5. Show these leaves in your class and ask your friends to name your tree. If necessary, give hints.

i wonder...
Rediscovering school science

Contributed by:
Swati Sidhu works with SeasonWatch, a citizen science project that monitors tree phenology in India. You can write to her at swati@ncf-india.org

Azim Premji University

Life in your Backyard

TREES AROUND YOU

1. Take a walk in your school campus or around your home and look at any 10 trees.
2. In the table, write down the name of each tree, if you know it. If you don't, make up a name for your tree.
3. For each tree, check to see if they have leaves, flowers, and fruits. If they do, write 'yes' in the table. If they don't, write 'no'.
4. Once you've finished doing this for all 10 trees, compare to see how many of them have all three: leaves, flowers, and fruits.
5. Are all the trees doing the same things or are there any differences?
6. Tell your class about what you find.

Number	Tree Name	Leaves	Flowers	Fruits

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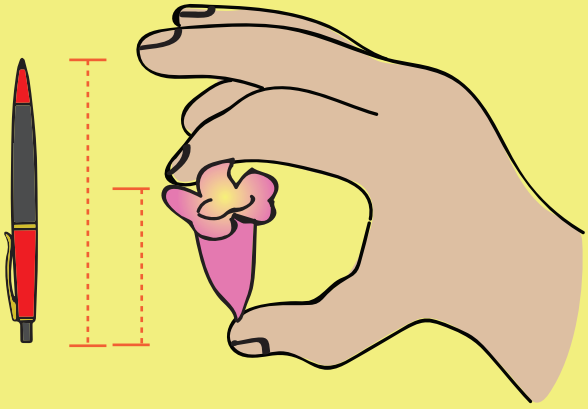
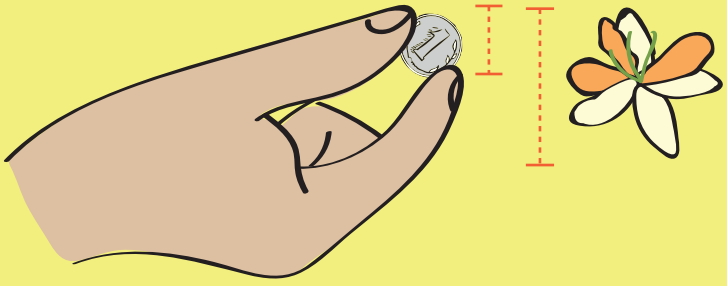
Life in your Backyard

FLOWERS AND THEIR VISITORS

Comparing flower sizes relative to known objects



Flower length half that of a pen



Flower width twice that of a coin

1. Look for two flowering plants (trees, shrubs or herbs) that you can observe at leisure.

2. Observe the flowers on both plants carefully - what colour are the flowers? What is their general shape (round, star-shaped, triangular, cylidrical etc)? How large (long and wide) are they? You can relate their size to a known object like a pencil, coin, the palm of your hand, etc. You could also make rough drawings to illustrate and take notes.

3. Pick one of these two plants and spend ten minutes observing animals that visit its flowers. Note the kind of animals (ant, spider, butterfly, bee, bird etc) that visit the flowers and count their numbers. Also, carefully see what the animals are doing when they are on the plant. Remember to note down which one of the two plants you are observing and the time of your observation (eg. 9:00 am to 9:10 am).

4. Do you know the names of your two plants? If not, choose a name for them based on what you have learnt. Share your findings with your class.

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Life in your Backyard

FLOWERS AND THEIR VISITORS

Record your observations here

Flower Details

	Flower 1	Flower 2
Size		
Shape		
Colour		

Animal Visitors

Plant:

Time:

	Kind of Animal	Number of Animals
Animal 1		
Animal 2		
Animal 3		
Animal 4		

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Note:

1. Image used in the background of the article title — *Semal* in bloom. Credits: Dinesh Valke. URL: https://www.flickr.com/photos/dinesh_valke/425565846. License: CC-BY-SA.
2. Image of Babool bloom used on page 61 — *Acacia nilotica* flowers. Credits: TREEAID. URL: https://www.flickr.com/photos/53871588@N05/5749766025. License: CC-BY.

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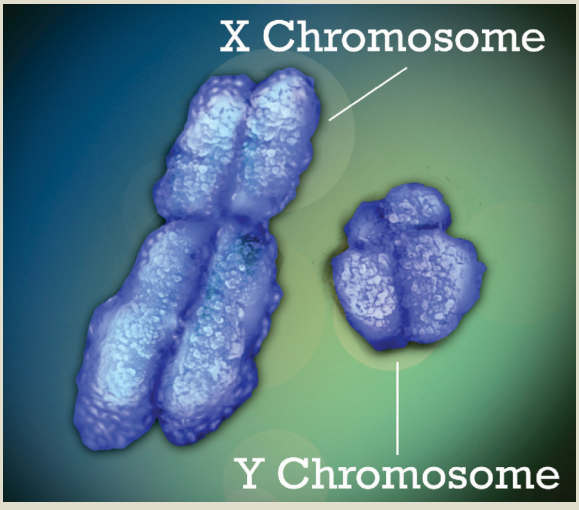
SNIPPETS

WHERE DOES THE GIRL CHILD GET HER 'X' CHROMOSOMES FROM?



The human X and Y chromosomes determine the sex of an individual.
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In humans, females have 'X, X' sex chromosomes, and males have 'X, Y' sex chromosomes.

But where does a girl child receive her two 'X' chromosomes from?

- Her father receives his 'X' chromosome from his mother, because all females are 'X, X' and contribute one 'X' to each of their eggs, irrespective of whether the egg gives rise to a male or female child. Similarly, her father receives his 'Y' chromosome from his father.
- The X and Y chromosomes in the girl's father cannot recombine because, unlike autosomes, they are dissimilar. So the father passes on an unchanged copy of the 'X chromosome' he receives from his mother to his daughter.

Therefore, a girl child receives one 'X' chromosome from her mother, and the other 'X' chromosome from her paternal grandmother (through her father)!

Rohini Chintha is an Assistant Professor (C) at the Department of Genetics and Biotechnology, University College for Women, Hyderabad. She is passionate about writing for children, and believes that 'A Happy Childhood builds a Happy Society'. About 85 of her stories for children have been published in various magazines.